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January 24, 2017

Mr. William Werkheiser, Acting Director
U.S. Geological Survey
12201 Sunrise Valley Drive, Mail Stop 100
Reston, VA 20192

Dear Acting Director Werkheiser,

The Scientific Earthquake Studies Advisory Committee (SESAC) held a conference call to discuss the recent report "Analysis of the Benefits and Costs for the Adoption of EarthScope Stations in Alaska", August 31, 2016, written by the Alaska Earthquake Monitoring Working Group (AEMWG). If action items of the report were implemented, there would be severe consequences for the USGS Earthquake Hazards Program. Because the SESAC takes the broad view of the entire Earthquake Hazards Program, we felt that we had to comment on this report. Our comments are in the attached document: Report of the Scientific Earthquake Studies Advisory Committee (SESAC), Conference Call January 5, 2017.

With warm regards,

Ralph J. Archuleta, Chair of SESAC
Research Professor and Emeritus Professor

cc: David Applegate, Associate Director, Natural Hazards
William Leith, Program Coordinator, Earthquake Hazards Program
Members, Scientific Earthquake Studies Advisory Committee

# Report of the Scientific Earthquake Studies Advisory Committee (SESAC)
# Conference Call January 5, 2017

The SESAC (membership listed in Appendix A) held a conference call on January 5, 2017 to discuss and provide recommendations related to the report, "Analysis of the Benefits and Costs for the Adoption of EarthScope Stations in Alaska", August 31, 2016, written by the Alaska Earthquake Monitoring Working Group (AEMWG) (Appendix A). The consensus of the SESAC is that the report articulates a cogent case for the benefits of improved earthquake monitoring in Alaska. SESAC has previously noted that the US effort in earthquake research is badly lagging relative to the threat that earthquakes pose to the wellbeing of the nation. The AEMWG report also notes on page 8, "The limited availability of federal funding for earthquake monitoring requires that earthquake monitoring needs in the contiguous states be balanced with needs in Alaska. The latter issue is beyond the scope of this report, which only considers the needs and benefits of monitoring in Alaska."

SESAC's responsibility in support of the USGS is to consider the breadth and balance of earthquake studies for the entire nation, and with that in mind we strongly advise against adoption of the Alaska EarthScope stations at this time. The proposed adoption of stations in Alaska would come at a cost that would dramatically undermine earthquake-monitoring capabilities in the contiguous United States, which are already eroding.

Table 1 shows the expected level of funding required for the enhanced Alaska monitoring along with current annual operating costs of the existing Alaska network. This ambitious effort would require an initial capital outlay of slightly over $5 million and annual operating costs of slightly over $2.7 million.

*Table 1*: ALASKA NETWORK FUNDING

| | | | |
|---|---|---|---|
| | Proposed Alaska EarthScope Station Adoption | $5.1 million one-time capital expenditure | $2.4 million annual operating cost |
| 2016 | Current Alaska Earthquake Center | | $1.35 million annual operating cost |

To put these requirements in perspective, SESAC requested an accounting from the USGS of regional earthquake monitoring networks that have recently been de-funded due to budgetary constraints. Cecily Wolfe, ANSS Coordinator and Associate Coordinator for Earthquake Hazards, Global Seismographic Network, and Geomagnetism Programs provided the following list:

*Table 2*: RECENTLY DEFUNDED REGIONAL NETWORKS

| Year Defunded | Regional Network | Operator | Annual Operating Cost |
|---|---|---|---|
| 2007 | Virginia Tech Seismic Network | Virginia Tech | $28,000 |
| 2007 | Kentucky Seismic and Strong Motion Network | University of Kentucky | $37,100 |

| | | | |
|---|---|---|---|
| 2012 | New England Seismic Network | Boston College | $200,000 |
| 2015 | ANZA Broadband Seismic Network | Univ. of California, San Diego | $110,000 |
| 2015 | Montana Regional Seismic Network | Montana Bureau of Mines and Geology | $70,000 |

These cuts amount to a total of about $466,000/year and have led directly to diminished earthquake monitoring capability in 10 states (Virginia, Kentucky, Massachusetts, New Hampshire, Rhode Island, New York, Vermont, Maine, California, and Montana). Compare this with the annual operational costs for the proposed Alaska adoption, *which is over five times this amount*, and according to AEMWG are likely to be underestimated. The SESAC concludes that implementing the Alaska station adoption under current budgetary constraints has the potential to cripple earthquake-monitoring capability for the rest of the nation.

To further put the cost of the AEMWG report in perspective: the population of Alaska is about 740,000. Almost 180 million people in the US live east of the Mississippi River and are also at risk from earthquakes. The USGS Earthquake Hazards Program (EHP) has requested an additional $800,000 per year in the 2016 President's budget in order to cover the current total cost (approximately $1.4M/year) of operating an additional 160 EarthScope stations east of the Mississippi River. These requested funds are far from being certain in the final FY2017 appropriations even though a sizeable percentage of 180 million people and related infrastructure, including almost all of the nation's nuclear power reactors, are at risk.

The SESAC wrote a special letter (September 23, 2015, Appendix B) that was sent to the Director of the USGS and forwarded to members of Congress. In this letter the SESAC highlights many of the areas in which EHP cannot extend itself, even though these are all areas of high priority in monitoring earthquakes and mitigating their effects. SESAC recommended that EHP determine what the real cost would be for the EHP to undertake substantial new initiatives that will mitigate the hazards and risks to our nation. The SESAC also agrees with the estimated budget for the USGS that was recommended by the National Research Council assessment of NEHRP in 2011[1]: ~$190M. Given that the current annual EHP budget (approximately $60M) is less than one third of this, opportunities such as the acquiring EarthScope stations in Alaska cannot be pursued without causing a severe misalignment of the current priorities in the EHP.

The SESAC has recommended to the EHP that there must be a balance in the budget between monitoring and applied research. It seems that it is always easier to find funding for collecting data than for the research that uses the data to improve or find new methods that lead to mitigation of the hazard. Over the past five years the EHP has successfully maintained that balance between monitoring and applied research, but if the provisions in the AEMWG report are implemented, all of the new funding would go for monitoring, with no budget for the

[1] National Earthquake Resilience: Research, Implementation, and Outreach (2011). National Research Council of the National Academies, The National Academies Press, Washington, D.C., ISBN: 978-0-309-18677-3, DOI: 10.17226/13092, 278 pp.

research that makes use of that data. These issues of balance and/or misalignment are critical concerns for the SESAC.

The EHP has continued its exceptional work with a nearly constant budget for almost 30 years. The consequence of a flat budget for so many years is that the EHP priorities have naturally been tailored to the most fundamental and critical programs necessary to meet the EHP's obligations to monitor earthquakes and mitigate their effects. As the SESAC wrote in September 2015 (Appendix B), there are many areas where the EHP could and should expand its role and offer greater public safety against seismological hazards, but is forced by a flat budget to stand down. Adoption of the additional EarthScope stations in Alaska recommended by this report is a perfect example of such an opportunity.

The Government Accounting Office has documented that the EHP is one of the most efficient and best-run programs in the government. EHP has impact. To cite one example, the EHP national seismic hazard maps (NSHMs) influence one trillion dollars' worth of new construction each year in the US. Efficiency also has a cost: the USGS has recently determined it is necessary to scale back the scope of web based Seismic Mapping tools used nationally by engineers to access the NSHMs, due to increasing IT expenses and greater demand for available resources elsewhere in the EHP program.

The AEMWG report on the adoption of EarthScope stations in Alaska cannot be looked at in isolation. With its current budget the EHP is at its limit of what it can do to reduce seismic risks in the US. The EHP's monitoring and applied research is a coordinated, balanced effort to mitigate the seismic hazard for the 143 million people who are at risk in the United States[2]. The EHP could do so much more for this great nation, but not with the budget it has. Thus, the SESAC cannot support the recommendations of the AEMWG report.

[2] Jaiswal, K. S, M. D. Peterson, K. Rukstales and W. M. Leith (2015). Earthquake Shaking Hazard Estimates and Exposure Changes in the Conterminous United States, *Earthquake Spectra*, Vol. 31, No. S1, pp. S201-S220.

**Appendix A**
Attending the SESAC conference call of January 5, 2017: SESAC, USGS and Guests

**SESAC members**

| | | |
|---|---|---|
| Ralph Archuleta | Chair, SESAC | Research Professor and Professor Emeritus, Earth Science, University of California, Santa Barbara, Santa Barbara, CA |
| John Anderson | Chair, National Seismic Hazard Map Committee | Professor, Seismology, University of Nevada, Reno, NV |
| Greg Beroza | Chair, USGS Advanced National Seismic System (ANSS) | Professor, Geophysics, Stanford University, Stanford, CA |
| Roland Burgmann | Chair, National Earthquake Prediction Evaluation Council (NEPEC) | Professor, Earth and Planetary Science, University of California, Berkeley, CA |
| Goran Ekstrom | SESAC | Professor, Earth and Environmental Sciences, Columbia University and Lamont Doherty Earth Observatory, NYC, NY |
| Julie Furr | SESAC | Professional Engineer, Chad Stewart and Associates Engineering, Inc., Lakeland, TN |
| Janiele Maffei | SESAC | Professional Engineer, Chief Mitigation Officer, California Earthquake Authority, Sacramento, CA |
| Tim Melbourne | SESAC | Professor, Geological Sciences, Central Washington University, Ellensberg, WA |
| Maureen Long | SESAC | Associate Professor, Geology and Geophysics, Yale University, New Haven, CT |
| Robert Pekelnicky | SESAC | Principal Engineer, Degenkolb Engineers, San Francisco, CA |

**USGS Staff**

| | | |
|---|---|---|
| William Leith | Senior Science Advisor for Earthquake and Geologic Hazards and Coordinator, USGS Earthquake Hazards Program | USGS, Reston, VA |
| Cecily Wolfe | ANSS Coordinator and Associate Coordinator for Earthquake Hazards, Global Seismographic Network, and Geomagnetism Programs | USGS, Reston, VA |
| Steve Hickman | Director, Earthquake Science Center | Menlo Park, CA |
| Jill McCarthy | Director, Geologic Hazards Science Center | Golden, CO |
| Mike Blanpied | Associate Coordinator, USGS Earthquake Hazards Program | Reston, VA |

**Guests**

| | | |
|---|---|---|
| Mike Mathis | Continental Resources | Oklahoma City, OK |
| Garry Maurath | California Energy Commission | Sacramento, CA |

**Alaska Earthquake Monitoring Working Group**

| | | |
|---|---|---|
| C.B. Crouse | Principal Engineer | AECOM, Seattle, WA |
| Jeffrey Freymueller | Professor of Geophysics | University of Alaska, Fairbanks, AK |
| Doug Given | Seismologist | United States Geological Survey, Pasadena, CA |
| Peter Haeussler | Geologist | United States Geological Survey, Anchorage, AK |
| Steve Masterman | State Geologist | Alaska Department of Natural Resources, Fairbanks, AK |
| Michael O'Hare | Director | Division of Homeland Security and Emergency Management, Fort Richardson, AK |
| David Oppenheimer | Chair, Seismologist (Emeritus) | United States Geological Survey, Menlo Park, CA |
| Susan Schwartz | Professor of Seismology | University of California Santa Cruz, Santa Cruz, CA |
| Paul Somerville | Seismologist | AECOM, Pasadena, CA |
| Paul Whitmore | Director | NOAA/National Weather Service National Tsunami Warning Center, Palmer, AK |
| David Wilson | Seismologist | United States Geological Survey, Albuquerque, NM |

**Appendix B**

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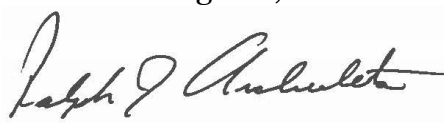
September 23, 2015

Dr. Suzette Kimball, Director
U.S. Geological Survey
12201 Sunrise Valley Drive, Mail Stop 100
Reston, VA 20192

Dear Director Kimball,

After discussions of the Scientific Earthquake Studies Advisory Committee (SESAC) meeting September 1, 2 at Southern Methodist University, we felt that there was an urgent and imperative need to supplement our report of July 28, 2015. I have attached a special letter to you and the Congress from SESAC.

With warm regards,



Ralph J. Archuleta, Chair of SESAC
Research Professor and Emeritus

cc: Members, Scientific Earthquake Studies Advisory Committee
David Applegate, Associate Director, Natural Hazards
William Leith, Program Coordinator, Earthquake Hazards Program

**Special Letter to Director of the US Geological Survey and the Congress from the FACA Scientific Earthquake Studies Advisory Committee (SESAC)**

September 23, 2015

The Scientific Earthquake Studies Advisory Committee (SESAC) is increasingly concerned that the USGS Earthquake Hazards Program (EHP) has fallen behind in its ability to properly monitor earthquake activity and advise the nation on the assessment of and response to earthquake hazards. This situation results not from deficiencies in leadership, ability or commitment within the EHP, but from chronic underfunding of the program. In spite of significant advances in increased awareness of earthquake hazards across the nation and in observational technology, the scope and core support for the program has not changed significantly since it was established in 1977. The impact of stagnant funding has been compounded over the past decade by disturbing changes in our assessment of earthquake hazards in parts of the US and exciting—but as yet unfulfilled—opportunities for enhanced observations and response:

- There has been a fundamental change in the assessment of the earthquake hazard in the Pacific Northwest since the Earthquake Hazards Program was established. It is now recognized that this region is capable of a significant subduction zone earthquake and tsunami, similar to recent devastating megathrust events in Sumatra, Japan and Chile.
- Unprecedented increases in seismicity in regions of hydrocarbon production in Oklahoma, Texas, Kansas and elsewhere have prompted concerns about seismic hazard in regions of the U.S. previously considered to be essentially aseismic. While the detailed mechanism responsible for this new class of human-influenced seismicity deserves additional investigation, it is clearly related to recent changes in drilling technology and disposal of fluid wastes.
- The August 2011, magnitude 5.8, Mineral VA earthquake, which caused significant damage in Washington DC, was a reminder of the potential for significant damage from moderate earthquakes in relatively stable parts of the central and eastern US.
- Modern observational systems that provide rapid, automatic identification and quantification of earthquake occurrence have allowed other nations, such as Japan and Mexico, to develop Earthquake Early Warning systems; however, the infrastructure necessary to implement a similar system in the western US is well beyond the resources currently available to the USGS.

SESAC is sending this letter, supplementing its annual report of July 2015, to emphasize that these recent developments in earthquake science and technology present valuable opportunities for the USGS Earthquake Hazards Program to benefit society. Over the past two years our committee has systematically reviewed all aspects of the current USGS Earthquake Hazards Program. We are impressed with the quality, efficiency, and value of their activities in impacting the short-term and long-term risk reduction within the entire US. The Earthquake Hazards Program is continually forced, however, to bypass opportunities that could initiate quantum changes in the understanding of earthquakes and in mitigating seismic risk. This letter summarizes opportunities that could be realized with adequate support.

This list of opportunities and needs is followed by a brief discussion of each:

1. An article by Kathryn Schulz in the New Yorker[1] vividly describes the potential for a catastrophic earthquake, perhaps reaching magnitude 9.0 or higher, in the Pacific Northwest—Washington, Oregon, and northern California. The earthquake could, plausibly, cause more than 13,000 deaths and hundreds of billions of dollars in damage with serious economic consequences affecting the US for many years thereafter.
2. If an earthquake similar to the historic 1755 Cape Ann, Massachusetts, earthquake that was felt from Washington DC to Montreal with damage from New Haven, Connecticut, to Portland, Maine, including Providence and Boston, were to reoccur in the Eastern and Central US, the economic and human losses would be severe given the population density of this region, the large area affected by shaking in the Northeast, the older and more vulnerable construction, and the general lack of preparedness.
3. Recent dramatic increases in the rate of earthquakes occurring in the Eastern and Central U.S., associated with injection of waste fluids have alerted both residents and scientists that earthquake hazard lurks in places—including urban areas such as Oklahoma City, OK and Dallas, TX—where few expected it. Scientific understanding of induced earthquakes can reduce uncertainty about how large such earthquakes might become and may lead to injection procedures that mitigate the hazard during the disposal of the waste fluids.
4. Southern California is overdue for a major earthquake with a magnitude greater than any felt there in the past 150 years. While major metropolitan areas, such as the city of Los Angeles, are taking steps to prepare[2], the shaking will be strongly influenced by the local geological conditions as well as the evolution of the earthquake rupture. Similarly the San Francisco Bay area is primed for a repeat of a major earthquake on the Hayward Fault that cuts through communities whose aggregate population exceeds one million.
5. Where seismic networks are adequate Earthquake Early Warning technology can provide a *ShakeAlert* for strong shaking expected at a certain time. The *ShakeAlert* can trigger automated safety responses and, in some cases, alert millions of people before they experience the shaking. Applications that will satisfy the public demand require more extensive seismic networks and robust computer systems designed for 100% reliability under the extreme conditions that will occur during a severe earthquake.
6. The USGS National Seismic Hazard Maps (NSHM) are basis for seismic design that inform $1 trillion dollars of construction annually. There are continual requests for improvement or additions to the NSHM, which are updated on a six-year cycle. By taking advantage of space geodesy, the densification of seismic networks, and state-of-the-art computer simulations, the USGS could reduce the uncertainty in its estimates of seismic hazard. Given this more accurate information, the design and construction would become more economical across the nation.
7. The demand for regional earthquake scenarios to estimate losses far exceeds the Earthquake Hazards Program's capability to generate them. Communities throughout the US use such scenarios for preparation and planning. Their ability

[1] Kathryn Schulz, "The Really Big One", The New Yorker, July 20, 2015.

[2] Resilience by Design, Dec. 8, 2014, http://www.lamayor.org/earthquake (accessed 9/13/2015)

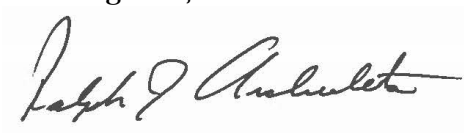
to respond before and after an earthquake depends on a reasonable estimate where the losses will be greatest.

Recent earthquake occurrences along with increases in knowledge in the fields of earthquake science and engineering have made us realize that we, the members of SESAC, would be irresponsible in our mandated reporting to Congress if we did not point out that 1) the number and importance of these critical issues are greater than at any time in our collective memory; 2) it is possible for the USGS to undertake substantial new thrusts that will mitigate the hazard and risk to our great nation, 3) the scope of the work that should be done far exceeds the budget of the USGS Earthquake Hazards Program.

At this stage, SESAC does not have sufficient information to be specific about the levels of capital investment and increased annual support that would be required to return the Earthquake Hazard Program to a healthy and beneficial level. We are convinced, however, that minor, incremental changes in funding will not suffice. Substantial increases in capital and operational support will be required to sustain a program responsive to current and emerging needs.

We strongly encourage the USGS to undertake a major assessment of the cost of a re-vitalized Earthquake Hazard Program that is comprehensive in its goal of ensuring a safer and more resilient nation. Because of the cumulative impact of decades of under-funding and the need to quickly assess the impact of significant recent changes in earthquake science and observations, it is essential that this study be undertaken without delay, and we hope you will consider this urgency in your 2017 budget planning.

With regards,



Ralph J. Archuleta
Chair, Scientific Earthquake Studies Advisory Committee (SESAC)